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STUDY THE EFFECT OF PACKAGING AND PRE-PACKAGING TREATMENTS ON SHELF LIFE AND QUALITY OF MINIMALLY PROCESSED FRESH GARLIC

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ABSTRACT

Minimally processed fresh garlic (whole and sliced) is gaining popularity in the market of fresh produce. Processing not only add value to the product, but also makes it more convenient to the consumers. The effect of packaging materials, e.g. polypropylene thick (PPH), polypropylene thin (PPL) & polyethylene (PE) and dipping treatments, e.g. hydrogen peroxide solution (0.2%), potassium permanganate (0.02%) & citric acid (2%) on the quality of minimally processed garlic was investigated. Garlic (Allium sativum L.) heads of Improved Balady variety were used. Whole and sliced dehulled cloves were dipped in different dipping solutions and packaged in different pouches and stored in refrigerator at 4°C. Weight loss, TSS, pH, microbiological and sensory attributes were studied. The data indicated that the mean values of weight loss for fresh whole and fresh cut garlic gloves packaged in PPH were lower than those of other packaging materials. The mean values of TSS for fresh whole garlic packaged using PPH and PPL showed same values for hydrogen peroxide and potassium permanganate treatments, 26.0 and 26.25, respectively, whereas the mean value of TSS for fresh cut garlic packaged in PPH was higher than those packaged in PE and PPL after 18 days of storage. The mean values for microbial counts of fresh whole garlic treated with potassium permanganate (0.02%) were lower than those treated with hydrogen peroxide (0.2%). While, the mean values of fresh cut garlic treated with citric acid (2%) were lower than that other tested dipping solutions. packaging materials and dipping solutions of fresh whole and fresh cut garlic did not cause any clear effect on studied sensory attributes. The polypropylene thick (PPH) showed better results in comparison with other packaging materials for both fresh dehulled whole and sliced garlic during storage. The potassium permanganate (0.02%) was the best dipping treatment for fresh whole garlic while citric acid (2%) was the best dipping treatment for fresh cut garlic.

INTRODUCTION

The consumer demand for high quality foods requiring only minimum amount of effort and time for preparation has led to the introduction of ready-to-use, convenience foods preserved by mild methods (so-called minimal processing methods) only. Minimally processed fruits and vegetables consist of raw fresh cut produce, which have undergone a minimal processing such as peeling, slicing or shredding to make them ready-to-use. Fresh cut vegetables are usually packed in sealed pouches or trays made of polymeric films (Raija, 2000).

Hydrogen peroxide is a colourless liquid which is soluble in water. It does not appear in the European Communities Regulations 1997 on Control of Additives for use in Foodstuffs, however it is found naturally in many foods as a result of microbial metabolism. Its antimicrobial properties have been known for many years and it has been widely used as a sterilant for aseptic

packaging. In the USA hydrogen peroxide is an approved bactericide for some dairy products and is used for disinfecting fruit and vegetables (Juven and Pierson, 1996). Its activity is due to its oxidising effects on bacteria and it also bleaches mushrooms during the soaking period. A 5 % (v/v) solution was used in the experiments reported below.

El-Sayad *et al.*, (1997) said that prevention of human fascioliasis could depend on clearing of the leafy salads from the metacercariae. The authors evaluated the role of some chemicals in detaching and killing this infective stage. Washing in running water alone for 10 minutes detached only 50% of metacercariae. Potassium permanganate; KMNO4 (24 mg/L) detached all metacercariae after 10 minutes exposure. The use of vinegar and KMNO4 is recommended. The first is lethal to other parasites in the vegetables, the second destroyed the metacercariae. Vegetable leaves were not softened and maintained fresh.

Washing procedures generally result in a one or two logs reduction in microbial counts. The efficacy of various disinfectants and sanitizing methods varies greatly, depending on the fruit and vegetable surface and the type of microorganism, physiological stage and environmental stress conditions (Beuchat, 1998).

Minimally processed fruits and vegetables (MPFV) are thoroughly washed and often dipped in antimicrobial solutions during processing. Washing is done with water alone or by adding chlorine (100 ppm) or citric or ascorbic acid (1%) to the washing water. Chlorinated water from the washing bath on a line processing chicory salads was found to contain 10^3CFU/mL of bacteria, being a source for contamination (Francis *et al.,* 1999).

Peeled garlic, cut onion and soybean sprouts were treated by dipping them in solutions of grapefruit seed extract (GFSE) and antibrowning agents. Microbial quality and browning were monitored during subsequent 7 day storage. Treatment by 250 mg·L-^{1}GFSE solution inhibited the growth of microorganism on peeled garlic and cut onion, but reduced microbial population only marginally on soybean sprouts which have heavy microbial loads. The effect of a 250 mg·L-1GFSE solution was comparable to that of a 100 mg·L-1 chlorine solution in decreasing microbial load and growth on peeled garlic and cut onion (Park, 1999).

Whole peeled garlic cloves are a popular convenience product processed originally for foodservice but now found in retail food stores. The fresh peeled cloves are packed in rigid clear plastic containers or in plastic film liners in carton boxes. The mechanical peeling process results in broken and damaged pieces, and damage is the major factor leading to decay and quality loss during storage. Storage at 0 to 5°C is imperative to maintain good quality. A 2 to 3 week storage-life is expected if kept at 5°C or below. Storage temperatures above 5°C will result in pink and brown discoloration on the damaged areas, and favor root and sprout development (Kang and Lee, 1999; Park, 1999).

The numbers and types of microorganisms found on fresh produce are highly variable. Mesophillic bacteria are around 10^3-10^9 CFU/g in raw vegetables after harvest depending on the produce and its growing conditions. Epiphytic bacteria may be more accessible to chemical treatment

than pathogens that may be hidden within plant tissues or protected by damaged tissues (Zagory, 1999).

(Woo *et al.* 1999). Studied The effect of unit operational procedures on the quality of minimally processed vegetables. Peeling methods were studied for garlic, while different preparation forms were tried for garlic, green onion and soybean sprouts. Washing and a mild heat treatment, at 60°C for 30s, were investigated as measures to reduce microbial populations of minimally processed vegetables They found that dry peeling was better than wet peeling in reducing microbial populations and preserving ascorbic acid content with garlic. For garlic and green onion, microbial quality deteriorated with severity of cutting. Washing reduced microbial counts of prepared vegetables.

The effect of washing treatments on microbiological quality of leafy vegetables such as lettuce serviced at university restaurants has been of great concern (Soriano *et al.*, 2000). They analyzed 144 lettuce samples from 16 university restaurants for their microbial contents. When sodium hypochlorite or potassium permanganate solutions were used in washing procedure, the aerobic microorganisms were reduced by more than two log units, and the total coliforms by at least one log.

Minimal processing also includes trimming, scrapping, slicing/dicing, shredding/chopping, moisture removal by centrifugation, packaging (MAP, 2-5% O_2, 3-10% CO_2), and storage at refrigeration temperature (2-5ºC). These processes have been shown to spread indigenous microflora and increase surface area of the produce for bacterial growth (Seymour *et al.*, 2002).

Minimum processing associated with an adequate packing system has shown good results in preserving a large group of perishable horticultural produce. (Soares, *et al.,* 2002) determined the effect of the number of layered of low-density polyethylene (LDPE) or polyvinyl chloride (PVC) film on the quality of minimally processed packed garlic (*Allium sativum*), known for its short shelf-life. Polystyrene trays containing 200 g garlic bulbils were wrapped in one to four layers of PVC or one or two layers of LDPE and stored at room temperature. Changes in weight, bulbils coloration, in-package gas composition and apparent quality were monitored for 14 days. Best results were obtained by wrapping the packages in four layers of PVC film, with insignificant weight loss (5%), changes in color tone and saturation, and the in-pack atmosphere (O_2 = 0.01% and CO_2 = 13.5%) inhibited fungal growth, extending shelf-life to 13 days at 25 ± 2°C. On the other hand, the high in-package moisture in LDPE wrapping favored fungal growth, rapidly depreciating bulbils quality. The shelf-life of minimally processed garlic can be increased by maintaining an adequate in-pack atmosphere, which can be achieved by using four layers of PVC or a another film of similar permeability.

Peeled garlic cloves are a convenient minimally processed vegetable and volumes have increased in retail and foodservice markets. Surface discoloration, moisture loss, and microbial spoilage contribute to loss of shelf life and quality in peeled cloves (Cantwell and Suslow, 2002).

The present study aimed to prolonging the shelf life and preserving the quality of fresh whole and sliced garlic cloves by utilizing the available simple and appropriate techniques for postharvest treatment and packaging. In

addition these techniques will increase marketing value and profitability and reduce contamination opportunities of fresh and processed garlic consumption.

MATERIALS AND METHODS

Materials:

Garlic Source: Clean fresh garlic (*Allium Sativum L.*) bulbs of Improved Balady variety were obtained from Horticultural Research Institute, Agriculture Research Center, Giza, season 2006 and were hand-dehulled before use in this study.

Package materials: Pouches (150x200 mm) were made of bi-axial oriented polypropylene (BOPP) of 20µ thickness (PPL), of 30µ thickness (PPH), and of low density polyethylene (LDPE thickness 30µ). LDPE material was bought from a local market, whereas the BOPP materials were donated by Egy. Wrap a local manufacturer of polypropylene film, 6 October City, Giza**.**

Chemicals: All chemicals materials used in this study were of food grades and were bought from the local market.

Methods:

Sample preparation: Prior to packaging, garlic heads were sorted and the good sound clean healthy ones were selected, divided into groups. Groups were randomly assigned to each of the treatment-combinations. After then hull was carefully removed by hand.

Dipping and packaging treatments:

Whole dehulled cloves: Clean sound dehulled garlic cloves were dipped for 2 min in hydrogen peroxide solution (0.2%) or in potassium permanganate solution (0.02%). After dipping, excess solutions were left to drain for 5 min. Seventy gram drained samples from each dip treatment were packaged in PPH and PPL pouches.

Sliced cloves: Dehulled garlic cloves were sliced (at 2-3 mm thickness) using a sharp knife. One-third of sliced samples was dipped for 2 min in citric acid (2.0%), another third of samples was dipped in hydrogen peroxide solution (0.2%), and the other third was packaged without dipping treatment (control). After dipping, excess solutions were left to drain for 5 min. About 70 g of sliced garlic samples were packed in PPH , PPL, or LDPE pouches.

Packaged whole and sliced garlic samples were stored refrigerated at 4°C. Random samples were withdrawn during storage for weight-loss , TSS, pH , microbial and sensory evaluation.

Loss in Weight (L.W.): Changes in garlic weight were monitored during storage, and calculated (average of three replicates) according to the following equation:

% L.W = (Initial weight - weight of garlic at sampling date) X 100/ Initial weight of garlic.

pH of garlic juice: The pH of the sap-expelled by pressing of garlic tissues was measured by using a bench top pH-meter.

Total soluble solids: The percentage of total soluble solids (TSS) of garlic sap was measured by using a hand held refractometer.

Microbial enumeration: The microbial contents of garlic samples were determined according to the methods described in the DIFCO manual (DIFCO, 1979). Acidified potato dextrose agar and nutrient agar were used to enumerate yeast & Mold and total microbial counts, respectively. Other total count plates were incubated under anaerobic conditions in order to enumerate anaerobic bacteria. Three plates of these cultures were enumerated and expressed as colony forming units per gram sample (CFU/ g garlic) .

Sensory evaluation: Samples were evaluated by a group of trained panelists recruited from the Food Technology Research Institute. Color, texture, taste and smell attributes were evaluated for the degree of likeness and given a point from 5 on an opened scale. Where 1 is unlike most, and 5 is extremely liked.

Statistical analysis.: Statistical analysis was conducted using the SPSS Statistical Software Package v.11.5 . Comparisons among the main treatment means were made using Tukey's H.S.D at (P = 0.05).

RESULTS AND DISCUSSION

The present investigation aimed to prolonging the shelf life and preserving the quality of fresh whole and sliced garlic cloves so the results are presented in two major sections to facilitate demonstrations and discussion as follows:

I. Fresh whole garlic. **II.** Fresh cut garlic.

I. Fresh whole garlic:

- Changes in weight loss, TSS and pH of minimally processed fresh whole garlic during storage at 4°C.

Data in table (1) summarize the results of the analyses of variance mean squares for weight loss, TSS and pH of dehulled fresh whole garlic gloves during storage at 4°C.

The F-test indicated that the main squares of packaging (PKG), storage duration (DAYS), the two-way interactions of PKGxTRT and PKGxDAYS were highly significant for weight loss. Which indicated that the effect of package depends on the type of dipping treatment and also on the period of storage. In other words, a package that is good for a dipping treatment may not be as good for the other one and vice versa. Moreover, a package may minimize weight loss for a shorter period of storage time but enables greater weight loss if storage was maintained for longer time. Meanwhile the data showed that the treatment solutions (TRT), the two-way interactions of TRTxDAYS and the three-way interaction PKGxTRTxDAYS were not significant for this characteristic which indicated that the effects of TRT and DAYS were independent.

Table (1): Analysis of variance mean squares estimates for weight loss, total soluble solids (TSS) and pH of minimally processed fresh whole garlic during storage at 4°C.

Source of variance	Weight loss		TSS		pH	
	d.f	Mean squares	d.f	Mean squares	d.f	Mean squares
Packaging materials (PKG)	2	7.498 **	2	0.125 NS	2	0.048 NS
Dipping solutions (TRT)	2	0.346 NS	2	1.500 NS	2	0.032 NS
Storage duration (DAYS[1])	2	20.188 **	3	4.014 **	3	0.221 NS
PKG * TRT	4	0.967 **	4	2.250 *	4	0.054 NS
PKG * DAYS	4	2.204 **	6	0.514 NS	6	0.138 NS
TRT * DAYS	4	0.294 NS	6	2.000 *	6	0.085 NS
PKG * TRT * DAYS	8	0.126 NS	12	1.167 NS	12	0.088 NS
Error	27	0.138	36	0.764	36	0.088

[1] Days factor (storage durations) for weight loss has one degree of freedom (d.f) less because data at zero time were all zeros and were excluded from the analysis

***,** denote Significant at *P* level 0.05 and 0.01; respectively. NS = non-significant at *P* level 0.05.**

For TSS the statistical analysis of fresh whole garlic indicated that, the main factors; PKG and TRT, the two-way interaction PKGxDAYS and the three-way interactions PKGxTRTxDAYS were not significant. On the contrary, the effect of storage duration was highly significant. In addition, the two-way interactions PKGxTRT and TRTxDAYS were significant, which indicated that the effect of package depends on type of dipping treatment and the effect of TRT depends on the period of storage. In other words, a package that is good for a dipping treatment may not be as good for the other one. Whereas, the two-way interactions of PKGxDAYS was not significant, which indicated that the effects of PKG and DAYS on garlic TSS were independent.Also, it is noticed in Table (1) for garlic pH, that the main factors; PKG, TRT and DAYS, and their two-and three-way interactions were not significant. This indicated insignificant difference among different samples.

Table (2): Mean values of weight loss, total soluble solids (TSS), and pH of minimally processed fresh whole garlic during storage at 4°C.

Characteristics	Weight loss (%)				TSS				pH			
Packaging[1]	PP-H		PP-L		PP-H		PP-L		PP-H		PP-L	
Dipping solutions[2] / Storage durations (days)	A	Pr	A	Pr	A	Pr	A	Pr	A	Pr	A	Pr
0	0.00	0.00	0.00	0.00	23.75	25.25	25.0	25.75	5.65	5.83	5.85	5.85
4	0.67	1.50	0.96	0.82	24.0	25.0	25.0	26.0	5.90	5.70	5.90	6.10
11	1.08	1.85	1.37	1.13	26.5	26.25	26.5	26.25	6.33	6.40	6.53	6.45
15	1.54	2.97	2.18	1.56	26.0	26.25	26.0	26.25	6.48	6.38	6.60	6.45
LSD0.05 Packaging	0.312				0.466				0.111			
LSD0.05 D. solutions	0.312				0.466				0.111			
LSD0.05 DAYS	0.382				0.659				0.157			

[1] Package materials: PP-H = Polypropylene thick (30µ), PP-L= Polypropylene thin (20µ).

2 Dipping solutions (Treatments): A = Hydrogen peroxide (0.2%), Pr = Potassium permanganate (0.02 %).

The mean values of weight loss, TSS and pH for minimally processed fresh whole garlic packaged in Polypropylene thick (PPH) and polypropylene thin (PPL) stored at 4°C are shown in Table (2). The weight loss for fresh whole garlic increased with increasing the storage period. The change in weight loss of fresh whole garlic packaged in PPH and PPL were 1.54, 2.97% & 2.18 and 1.56% after 15 days of storage with hydrogen peroxide (0.2%) and potassium permanganate (0.02%), respectively.

The weight loss for fresh whole garlic packaged in PPH was lower than that packaged in PPL with hydrogen peroxide (0.2%). While, garlic treated with potassium permanganate (0.02%) packaged in PPL showed weight loss lower than that packaged in PPH.

For TSS the data indicated that, the mean values of fresh whole garlic increased slightly by the end of storage. The mean values of TSS for fresh whole garlic packaged in PPH and PPL showed same values with hydrogen peroxide (0.2%) and potassium permanganate (0.02%), i.e. 26.0 and 26.25, respectively.

Also, it is noticed that the mean values of pH of fresh whole garlic increased slightly with increasing the storage duration. The values of pH of fresh whole garlic packaged in PPH and PPL were 6.48, 6.38 and 6.60, 6.46 after 15 days of storage with hydrogen peroxide (0.2%) and potassium permanganate (0.02%) respectively. These results are in agreement with those of Fantuzzi (1999) and Bittencourtt *et al.* (2000).

- Changes in microbial counts of minimally processed fresh whole garlic during storage at 4°C.

The results of the analyses of variance mean squares for microbial counts of minimally processed fresh whole garlic during storage at 4°C are shown in Table (3).

With regard to total microbial count (T.C), the F-test indicated that the Mean squares of packaging (PKG) and the three-way interactions PKGxTRTxDAYS were significant.

Table (3): Analysis of variance mean square estimates for microbial counts of minimally processed fresh whole garlic during storage at 4°C.

Source of variance	d.f	Mean squares		
		T.C	Y&M	A.N
Packaging materials (PKG)	2	14.049 *	3.063 NS	3.396 *
Dipping solutions (TRT)	2	25.507 **	5.896 NS	8.896 **
Storage durations (DAYS)	3	894.19 **	65.731 **	5.229 **
PKG * TRT	4	3.247 NS	2.615 NS	0.667 NS
PKG * DAYS	6	12.021 **	1.683 NS	1.618 NS
TRT * DAYS	6	6.618 NS	3.238 NS	1.174 NS
PKG * TRT * DAYS	12	6.913 *	1.846 NS	0.500 NS
Error	108	3.153	2.338	1.035

***,** denote Significant at *P* level 0.05 and 0.01; respectively. NS = non-significant at *P* level 0.05**

While the treatments (TRT), storage (DAYS) and the two-way interaction PKGxDAYS were highly significant, which indicated that the effect of package materials depends on the duration of storage. Meanwhile, the two-way interactions PKGxTRT and TRTxDAYS were not significant for this

characteristic which indicated that the effect of storage and each of PKG and TRT on garlic T.C were independent.

For Yeast and Mold count, the statistical analysis indicated that only the effect of storage duration was highly significant. While the PKG, TRT, and the two- and three-way interactions were not significant which indicated insignificant differences among Y&M values of different PKG and TRT.

Also, it is noticed that for Anaerobic bacterial counts, the main values of packaging (PKG) was significant while, TRT and storage were highly significant. On the other hand, all the two-way interactions and the three-way interaction were not significant which indicated that the effect of PKG, TRT and DAYS on A.N values of different garlic samples were independent.

The mean values of Total microbial count (T.C), Yeast and mold count (Y&M) and Anaerobic bacterial counts (A.N) for minimally processed fresh whole garlic packaged in Polypropylene thick (PPH) and Polypropylene thin (PPL) stored at 4°C are shown in Table (4).

Data in Table (4) showed that the mean values of T.C, Y&M and A.N of fresh whole garlic increased with increasing the storage period. The mean values of T.C and Y&M for fresh whole garlic packaged in PPL were lower than that packaged in PPH for both dipping treatments, whereas for A.N, data showed that PPL had the highest values with potassium permanganate (0.02%).

Also, the data indicated that, the mean values for T.C, Y&M and A.N of fresh whole garlic treated with potassium permanganate (0.02%) were lower than that treated with hydrogen peroxide (0.2%). These results agree with Berrang *et al.* (1990) who demonstrated that, these microorganisms continued growing in asparagus, even if the sensory characteristics remained the same. The sanitary quality of minimally processed vegetables were studied by Valero *et al.* (2002) on garlic. Generally they found that, the products were safe when they were processed in hygiene conditions and stored under refrigeration temperatures

Table (4): Mean values of microbial counts (x103) of minimally processed fresh whole garlic during storage at 4°C.

Characteristics	Total microbial count				Yeast and Mold count				Anaerobic bacterial counts			
Packaging[1]	PP-H		PP-L		PP-H		PP-L		PP-H		PP-L	
Dipping solutions[2] / Storage time(days)	A	Pr	A	Pr	A	Pr	A	Pr	A	Pr	A	Pr
0	2.1	2.1	2.5	3.5	4.0	2.1	1.8	1.9	1.8	1.5	1.4	1.4
4	2.8	13.9	13.8	14.6	8.0	4.5	7.8	8.1	4.9	4.0	4.0	5.0
11	29.0	16.4	17.1	16.1	11.8	6.0	6.6	5.4	6.3	3.4	3.9	2.0
15	29.0	20.3	21.4	12.3	16.6	10.8	9.4	6.9	3.3	2.1	2.8	4.5
$LSD_{0.05}$ Packaging	3.547				1.387				0.950			
$LSD_{0.05}$ D. solutions	3.547				1.387				0.950			
$LSD_{0.05}$ DAYS	5.016				1.962				1.344			

[1] Package materials: PP-H = Polypropylene thick (30µ), PP-L = Polypropylene thin (20µ) .

[2] Dipping solutions (Treatments): A = Hydrogen peroxide (0.2%), Pr = Potassium permanganate (0.02 %).

- Changes Sensory attributes of minimally processed fresh whole garlic during storage at 4°C.

The results of the analyses of variance mean squares for sensory attributes of minimally processed fresh whole garlic during storage at 4°C are shown in Table (5).

Analysis of variance mean squares indicated that the Mean squares of TRT and DAYS were highly significant for color, texture, taste and smell. While the Mean squares values of PKG, all the two way interactions and the three-way interaction were not significant for these characteristics. This indicated that the effect of PKG, TRT and DAYS were independent.

Table (5): Analysis of variance mean square estimates for sensory attributes of minimally processed fresh whole garlic during storage at 4°C.

Source of variance	d.f	Mean squares			
		Color	Texture	taste	Smell
Packaging materials (PKG)	2	0.160 NS	0.333 NS	0.259 NS	0.259 NS
Dipping solutions (TRT)	2	2.420 **	3.815 **	3.000 **	3.000 **
Storage durations (DAYS[1])	2	4.679 **	4.111 **	2.704 **	3.815 **
PKG * TRT	4	0.309 NS	0.204 NS	0.037 NS	0.093 NS
PKG * DAYS	4	0.123 NS	0.167 NS	0.130 NS	0.074 NS
TRT * DAYS	4	0.049 NS	0.093 NS	0.037 NS	0.037 NS
PKG * TRT * DAYS	8	0.022 NS	0.065 NS	0.019 NS	0.046 NS
Error	54	0.247	0.210	0.235	0.198

[1] Days factor (storage durations) for sensory evaluation has one degree of freedom less because data at zero time were all fives and were excluded from the analysis.

***,** denote Significant at *P* level 0.05 and 0.01; respectively. NS = non-significant at *P* level 0.05.**

The mean values of panelists' scores for color, texture, taste and smell for minimally processed fresh whole garlic stored at 4°C are presented in Table (6).

Table (6): panelists' scores for sensory attributes of minimally processed fresh whole garlic during storage at 4°C.

Characteristics	color				texture				taste				smell			
Packaging[1]	PP-H		PP-L		PP-H		PP-L		PP-H		PP-L		PP-H		PP-L	
Dipping solution[2] / Storage time (days)	A	Pr	A	Pr	A	Pr	A	Pr	A	Pr	A	Pr	A	Pr	A	Pr
0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
4	4.7	5.0	4.7	4.3	4.7	5.0	5.0	5.0	4.7	5.0	4.3	4.7	4.3	4.7	4.7	4.7
11	4.3	4.7	4.0	4.0	4.3	5.0	4.7	4.3	4.3	4.7	4.3	4.0	4.0	4.3	4.0	4.0
15	3.7	4.3	4.0	3.7	4.0	4.3	4.0	4.0	4.0	4.3	4.0	3.7	3.7	4.0	4.0	3.7
$LSD_{0.05}$ Packaging	0.324				0.256				0.324				0.303			
$LSD_{0.05}$ D. solutions	0.324				0.256				0.324				0.303			
$LSD_{0.05}$ DAYS	0.397				0.314				0.397				0.371			

1 Package: PP-H=Polypropylene thick (30µ), PP-L= Polypropylene thin (20µ) & 2 Treatments: A = Hydrogen peroxide (0.2%), Pr = Potassium permanganate (0.02 %).

The data showed that the mean values of panelists' scores for color, texture, taste and smell attributes decreased with increasing the storage duration. It may be concluded that the packaging materials and the dipping treatments, hydrogen peroxide and potassium permanganate of fresh whole garlic did not cause any clear effect on studied sensory attributes.

From the previous discussions, it could be concluded that using the package Polypropylene thick (PPH) and the dipping treatment potassium permanganate were better in preserving the quality of fresh whole peeled garlic cloves than the other treatments; PPL and hydrogen peroxide.

II. Fresh cut garlic:

- **Changes in weight loss, TSS and pH of fresh cut garlic during storage at 4°C.**

Table (7) summarizes the results of the analyses of variance mean squares for weight loss, TSS and pH of fresh cut garlic during storage at 4°C.

Table (7): Analysis of variance mean square estimates for weight loss, total soluble solids (TSS) and pH of fresh cut garlic during storage at 4°C.

Source of variance	Weight loss		TSS		pH	
	d.f	Mean squares	d.f	Mean squares	d.f	Mean squares
packaging materials (PKG)	1	1.039NS	1	3.516*	1	0.289*
dipping treatments (TRT)	1	1.682*	1	4.516*	1	0.001NS
storage durations (DAYS[1])	2	5.780**	3	8.932**	3	1.977**
PKG * TRT	1	6.654**	1	0.141NS	1	0.000NS
PKG * DAYS	2	0.053NS	3	1.182NS	3	0.008NS
TRT * DAYS	2	0.023NS	3	1.682NS	3	0.031NS
PKG * TRT * DAYS	2	0.451NS	3	0.141NS	3	0.072NS
Error	47	0.361	48	0.859	48	0.049

[2]DAYS factor (storage durations) for weight loss has one degree of freedom less because data at zero time were all zeros and were excluded from the analysis

***,** denote Significant at P level 0.05 and 0.01; respectively. NS = non-significant at P level 0.05.**

The F-test for weight loss data indicated that the Mean square of packaging (PKG), was not significant, whereas those for dipping treatments and storage durations were significant and highly significant respectively. The two-way interaction of PKGxTRT was highly significant which indicated that, the effect of package depends on the type of dipping treatment and vice versa. Meanwhile, the data showed that the two-way interactions of PKGxDAYS, TRTxDAYS and the three-way interactions PKGxTRTxDAYS were not significant for this characteristic which indicated that the effect of DAYS on weight loss of garlic samples were independent from the effects of PKG and TRT.

For TSS, the statistical analysis indicated that, the effects of main factors; PKG and TRT were significant, moreover, storage durations were highly significant, whereas all the two-way interactions and the three-way interactions were not significant for this characteristic. This indicated that the effect of PKG, TRT and DAYS were independent.

It is noticed for pH that the effects of the main factors; PKG and DAYS were significant and highly significant effect respectively, whereas those of TRT, all the two-way interactions and the three-way interaction were not

significant. This indicated that the effect of PKG, TRT and DAYS were independent.

The mean values of weight loss, TSS and pH for fresh cut garlic treated with hydrogen peroxide (0.2%), citric acid (2%) packaged in Polyethylene (PE), Polypropylene thick (PPH) and polypropylene thin (PPL) stored at 4°C are shown in Table (8).

Weight loss for fresh cut garlic increased with increasing storage duration for dipping treatments and all packaging materials. Also the data showed that the highest values of weight loss for fresh cut garlic packaged in PE were 5.06, 4.23 and 3.35% while, the lowest values of weight loss were observed with fresh cut garlic packaged in PPH (2.42, 1.77 and 1.60%) after 18 days of storage with hydrogen peroxide (0.2%), control (No dipping) and citric acid (2%) respectively. Regarding the TRT, the hydrogen peroxide (0.2%) had the highest values compared with the citric acid (2%) for this characteristic.

For TSS the data indicated that, the mean values of fresh cut garlic increased with increasing the storage period (from 23.5 to 26.5) when treated with citric acid (2%) with all tested packaging materials compared with the control (decreased from 25.0 to 23.5) during storage durations. While the mean values for TSS of fresh cut garlic treated with hydrogen peroxide (0.2%) increased slowly (23.5-25.5) during storage. As well as the results showed that, the mean values of TSS for fresh cut garlic packaged in PPH was higher than that packaged in PE and PPL after 18 days of storage.

Also, it is noticed that the mean values of pH for fresh cut garlic increased with increasing the storage period with all tested packaging materials and treatments. The change in pH of fresh cut garlic packaged in PE, PPH and PPL were from 5.70 to 6.35 & 5.45 to 6.25 and 5.85 to 6.25 respectively, during storage durations. Similar results were obtained by Bittencourtt *et al.* (2000).

- Changes in microbial counts of fresh cut garlic during storage at 4°C.

The analyses of variance Mean squares for microbial counts of fresh cut garlic during storage at 4°C are shown in Table (9).

The F-test indicated that the main squares for total microbial count of PKG, TRT, the two way interaction PKGxTRT and the three-way interaction PKGxTRTxDAYS were not significant, which indicated that the effect of PKG and TRT were independent. While DAYS showed highly significant effect, but the two way interactions PKGxDAYS and TRTxDAYS were significant effect for T.C, which indicated that the effect of type of packaging and dipping solutions depends on the storage durations.

Concerning the Yeast and Mold count (Y&M), the statistical analysis indicated that the Mean square values for PKG and the two-way interaction PKGxTRT were significant, moreover, TRT, Days and the two-way interactions PKGxDAYS were highly significant. This indicated that the effect of type of packaging depends on the dipping treatment and on storage duration. On the contrary, the two-way interaction TRTxDAYS and the three-way interaction were not significant which indicated that the effects of TRT and DAYS were independentAlso, it is noticed that for Anaerobic bacterial counts, the Mean square of storage durations was highly significant.

T8

While the packaging, dipping treatments, all the two way interactions and the three-way interaction were not significant. This indicated that the effect of storage (DAYS) on A.N was independent of types of PKG or TRT.

Table (9): Analysis of variance mean square estimates for microbial counts of fresh cut garlic during storage at 4°C.

Source of variance	d.f	Mean squares		
		T.C	Y&M	A.N
Packaging materials (PKG)	1	101.5 NS	128.00*	2.531 NS
Dipping treatments (TRT)	1	171.13 NS	205.03**	9.031 NS
Storage durations (DAYS)	3	2290.05 **	386.9 **	52.77 **
PKG * TRT	1	2.000 NS	94.53*	18.00 NS
PKG * DAYS	3	321.010 *	73.65 **	11.052 NS
TRT * DAYS	3	376.396 *	19.64 NS	12.344 NS
PKG * TRT * DAYS	3	160.229 NS	2.260 NS	2.562 NS
Error	112	102.536	15.688	7.359

***,** denote Significant at *P* level 0.05 and 0.01; respectively. NS = non-significant at *P* level 0.05**

The mean values of microbial count for minimally processed of fresh cut garlic packaged in Polyethylene (PE), Polypropylene thick (PPH) and polypropylene thin (PPL)] stored at 4°C are shown in Table (10).

The data showed that the mean values of T.C, Y&M and A.N for fresh cut garlic increased with increasing the storage period with all tested packaging materials and dipping solutions. The mean values of T.C and Y&M for fresh cut garlic packaged in PPH were lower than that packaged in other tested packaging materials, while fresh cut garlic packaged in PE had the lowest values for A.N. Also, the data indicated that, the mean values of fresh cut garlic treated with citric acid (2%) were lower than that other tested dipping solutions. These results agree with Francis *et al.*, (1999).

- The panelists' scores for sensory attributes of fresh cut garlic during storage at 4°C.

The analyses of variance Mean squares for sensory attributes of fresh cut garlic during storage at 4°C are shown in Table (11).

Analyses of variance indicated that the Mean square of DAYS was highly significant for color, texture, taste and smell attributes scored by panelists. Effect of PKG was found to be significant for color and taste, while it was not significant for texture and smell. Meanwhile, the Mean squares of dipping treatments were not significant for all characteristics.

The two way interactions of PKGxTRT was significant for color and texture, while it was not significant for taste and smell. This indicated that the significant effect of package on color and texture scores depends on the type of dipping treatment. Also, the data showed that the two way interactions of PKGxDAYS were highly significant for the taste, which indicated that the effect of package on scores of taste depends on the storage duration. That type of interaction was not significant for the other characteristics. Meanwhile the two way interaction of TRTxDAYS was highly significant for the texture, but it was not for the other characteristics. The three-way interactions PKGxTRTxDAYS were not significant effect for all attributes.

T10

Table (11): Analysis of variance mean square estimates for sensory attributes of fresh cut garlic during storage at 4°C.

Source of variance	d.f	Mean squares			
		color	texture	taste	smell
Packaging materials (PKG)	1	1.000*	0.028NS	1.000*	0.000NS
Dipping treatment (TRT)	1	0.111NS	0.250NS	0.111NS	0.111NS
Storage durations (DAYS[1])	2	1.694**	2.111**	1.333**	1.750**
PKG * TRT	1	1.000*	0.694*	0.444NS	0.444NS
PKG * DAYS	2	0.083NS	0.111NS	0.000**	0.083NS
TRT * DAYS	2	0.028NS	0.000**	0.111NS	0.028NS
PKG * TRT * DAYS	2	0.083NS	0.111NS	0.111NS	0.028NS
Error	24	0.222	0.139	0.222	0.194

[1] **Days factor (storage durations) for sensory evaluation has one degree of freedom less because data at zero time were all fives and were excluded from the analysis**

***,** denote Significant at P level 0.05 and 0.01; respectively. NS = non-significant at P level 0.05**

The mean values of sensory attributes for fresh cut garlic packaged in Polyethylene, Polypropylene thick and Polypropylene thin stored at 4°C are presented in Table (12).

The data showed that the mean values of panelists' scores for color, texture, taste and smell attributes of fresh cut garlic decreased with increasing storage duration for all tested packaging materials and dipping treatments.

Comparison among means of color, texture, taste and smell scores at each storage period indicated that the average score with citric acid (2%) was higher than those of treated with hydrogen peroxide (0.2%) and control (No dipping) for treated minimally processed of fresh cut garlic. It may be concluded that the tested packaging materials for fresh cut garlic did not cause any clear effect on studied sensory attributes.

T12

CONCLUSION

From the previous results, it could concluded that regarding the package [Polypropylene thick (PPH), Polypropylene thin (PPL) & Polyethylene (PE)], the Polypropylene thick (PPH) was the best tested packaging for both fresh whole and cut garlic during storage. Concerning the dipping treatments**,** the potassium permanganate (0.02%) was the best dipping treatment for fresh whole garlic while, the citric acid (2%) was the best dipping treatment for fresh cut garlic.

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دراسة تأثير أنواع العبوات و معاملات ما قبل التعبئة على فترات الصلاحية وجودة الثوم الطازج محدود التجهيز

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حفظ الثوم طازج محدود التجهيز مهم جدا حيث أنه لا يضيف قيمة تسويقية للمنتج فقط ولكن يجعل الثوم ملائم وسهل الاستخدام بالنسبة للمستهلكين. تم دراسة تأثير ثلاثة أنواع من مواد التعبئة والتغليف وهى بولي بروبلين بسمك٣٠ ميكرون (PPH) وبولي بروبلين بسمك ٢٠ ميكرون (PPL) وبولي إثيلين منخفض الكثافة بسمك ٣٠ ميكرون (PE) والمعاملة بثلاثة محاليل غمر وهى برمنجنات البوتاسيوم بتركيز ٠,٠٢% و فوق أكسيد الهيدروجين بتركيز ٠,٢ % و حامض الستريك بتركيز ٢% على صفات الجودة للثوم الطازج محدود التجهيز للصنف البلدي المحسن. تم غمر عينات الثوم (فصوص مقشرة كاملة أو شرائح بسمك ٢-٣ مم) في محاليل الغمر المذكورة وتعبئتها في العبوات تحت الدراسة والتخزين على درجة ٤ درجة مئوية وتم سحب عينات على فترات زمنية لتقدير صفات الجودة للثوم و هي الفقد في الوزن , المواد الصلبة الكلية , pH ، الحمل الميكروبيولجي , والصفات الحسية.

أظهرت النتائج أن الفقد في الوزن بالنسبة للثوم السليم المقشر و الثوم المقطع والمعبأ في عبوة (PPH) كان اقل من تلك العينات في باقي العبوات تحت الدراسة. أعطت كل من العبوات (PPH) و(PPL) نفس القيم لصفة المواد الصلبة الكلية للثوم السليم المقشر والمعامل بأي من فوق أكسيد الهيدروجين أو برمنجنات البوتاسيوم ، لكن في حالة الثوم المقطع أعطت العبوة (PPH) قيماً أعلى من تلك المعبأة في عبوات (PE) و(PPL) بعد ١٨ يوم من التخزين. و بالنسبة للثوم السليم فإن المعاملة ببرمنجنات البوتاسيوم كانت أفضل من المعاملة بفوق أكسيد الهيدروجين حيث أنها أعطت قيم اقل للتقديرات الميكروبية التي تم دراستها ، ولكن كانت المعاملة بحامض الستريك بتركيز٢ % أفضل المعاملات في حالة الثوم المقطع. ووجد أن مواد التعبئة والتغليف ومحاليل الغمر المستخدمة ليس لها تأثير واضح على الصفات الحسية المدروسة. أوضحت النتائج أن العبوة بولي بروبلين (PPH) أفضل العبوات المستخدمة لكل من الثوم السليم والمقطع ، بينما كان الغمر في محلول برمنجنات البوتاسيوم (٠,٠٢) أفضل المعاملات بالنسبة للثوم السليم ، وفي حامض الستريك (٢%) بالنسبة للثوم المقطع.

Table (8): Mean values of weight loss, total soluble solids (TSS) and pH of fresh cut garlic during storage at 4°C.

Characteristics	Weight loss (%)									TSS									pH								
Packaging[1]	PE			PP-H			PP-L			PE			PP-H			PP-L			PE			PP-H			PP-L		
Treatments / Storage time (days)	A	B	S	A	B	S	A	B	S	A	B	S	A	B	S	A	B	S	A	B	S	A	B	S	A	B	S
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	25.5	25.0	23.5	23.5	24.5	24.5	24.5	25.0	23.5	5.70	5.80	5.90	6.20	5.55	5.45	5.95	6.05	5.85
6	0.83	0.72	0.79	0.48	0.49	0.63	0.34	0.50	0.82	24.0	23.5	24.5	23.5	23.5	24.5	23.5	25.0	25.5	6.00	5.85	6.10	6.05	5.65	5.60	6.35	6.00	6.20
11	2.81	1.90	1.58	1.19	0.96	1.06	0.92	1.25	1.77	25.5	25.0	24.5	25.5	23.5	26.0	24.5	25.5	25.0	6.20	6.05	6.00	5.85	6.25	6.15	5.65	6.00	5.90
18	5.06	4.23	3.35	2.42	1.77	1.60	1.83	1.87	2.32	25.5	23.5	26.5	25.0	25.0	26.0	25.5	24.5	25.0	6.10	5.95	6.35	6.00	6.10	6.25	6.15	6.10	5.85
$LSD_{0.05}$ Packaging	0.254									0.512									0.174								
$LSD_{0.05}$ D. solutions	0.254									0.512									0.174								
$LSD_{0.05}$ DAYS	0.254									0.591									0.201								

[1] **Package materials: PE = Polyethylene (30 µ), PP-H=Polypropylene thick (30 µ), PP-L= Polypropylene thin (20 µ) .**
2 Treatments: A = hydrogen peroxide (0.2%), S = citric acid(2%), B = the control (No dipping).

Table (10): Mean values of microbial counts of fresh cut garlic during storage at 4°C.

Characteristics	Total microbial count									Yeast and Mold count									Anaerobic bacterial counts								
Packaging[1]	PE			PP-H			PP-L			PE			PP-H			PP-L			PE			PP-H			PP-L		
D. treatments [2] / Storage time (days)	A	B	S	A	B	S	A	B	S	A	B	S	A	B	S	A	B	S	A	B	S	A	B	S	A	B	S
0	1.25	2.00	1.00	1.25	2.75	1.00	1.00	2.50	1.00	2.75	3.25	3.00	1.75	2.50	2.00	3.25	3.50	3.00	1.25	2.25	2.00	0.25	1.50	0.75	2.00	2.00	1.50
6	1.75	2.25	2.25	2.50	3.50	2.25	3.75	2.75	3.50	3.50	3.25	4.50	3.50	3.75	3.50	3.50	3.00	3.50	2.00	2.75	2.00	1.75	1.75	1.50	1.75	2.25	0.75
11	8.25	13.3	9.75	10.0	7.50	5.50	8.25	10.5	6.00	4.00	5.00	4.25	3.75	3.75	3.50	3.25	3.75	3.75	2.25	2.75	1.75	1.75	1.00	1.50	2.00	2.25	1.25
18	14.0	13.5	13.0	10.8	11.3	11.3	9.50	13.3	11.8	4.50	4.75	8.50	4.50	6.50	6.25	5.50	7.00	6.00	2.25	2.75	1.50	2.25	3.50	1.75	2.50	3.50	1.75
$LSD_{0.05}$ Packaging	**0.718**									**0.619**									**0.412**								
$LSD_{0.05}$ D. solutions	**0.718**									**0.619**									**0.412**								
$LSD_{0.05}$ DAYS	**0.830**									**0.714**									**0.475**								

[1] Package materials: PE = Polyethylene (30 µ), PP-H=Polypropylene thick (30 µ), PP-L= Polypropylene thin (20 µ) .
[2] Treatments: A = hydrogen peroxide (0.2%), S = citric acid(2%), B = the control (No dipping).

Table (12): Panelists' scores for Sensory attributes of fresh cut garlic during storage at 4°C.

Characteristics	COLOR									TEXTURE									TASTE									SMELL								
Packaging[1]	PE			PP-H			PP-L			PE			PP-H			PP-L			PE			PP-H			PP-L			PE			PP-H			PP-L		
D. treatmens[2] / Storage time (days)	A	B	S	A	B	S	A	B	S	A	B	S	A	B	S	A	B	S	A	B	S	A	B	S	A	B	S	A	B	S	A	B	S	A	B	S
0	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
6	4.67	4.33	4.67	4.67	4.00	5.00	4.33	4.00	4.67	4.67	4.00	5.00	4.33	4.33	5.00	4.67	4.00	5.00	4.67	4.00	5.00	4.33	4.33	5.00	4.67	4.00	5.00	4.33	4.00	4.67	4.00	4.00	4.67	4.33	4.00	4.67
11	4.00	3.67	3.67	4.00	3.67	4.33	4.00	3.67	4.33	4.67	3.67	4.67	4.00	3.67	4.33	4.33	4.00	4.67	4.67	3.67	4.67	4.00	3.67	4.33	4.33	4.00	4.67	4.00	3.67	4.33	3.67	3.33	4.00	4.00	3.33	4.00
18	3.67	3.33	3.67	3.67	3.33	4.33	3.67	3.33	4.00	4.00	3.33	3.67	3.67	3.33	4.00	4.00	3.67	4.33	4.00	3.33	3.67	3.67	3.33	4.00	4.00	3.67	4.33	3.67	3.33	3.67	3.33	3.00	4.00	3.67	3.33	4.00
$LSD_{0.05}$ Packaging	0.271									0.250									0.265									0.243								
$LSD_{0.05}$ D.solutions	0.271									0.250									0.265									0.243								
$LSD_{0.05}$ DAYS	0.271									0.250									0.265									0.243								

[1] **Package: PE = Polyethylene (30 µ), PP-H=Polypropylene thick (30 µ), PP-L= Polypropylene thin (20 µ)**

[2] **Treatments: A = hydrogen peroxide (0.2%), S = citric acid(2%), B = the control (No dipping)**